WQB "Wide Aperture Quad" for Main Injector

11 March 2004
IB2 conference room
9:00 AM

Attendees: Leon Bartelson, John Carson, Weiren Chou, TJ Gardner, Hank Glass, Dave Harding, Dave Johnson, Vladimir Kashikhin, Ioanis Kourbanis, François Ostiguy, John Zweibohmer

John Z. reported that we only have about 50,000 pounds of LTV steel left from the Main Injector, but the WQB magnets will need about 200,000 pounds. He has a budgetary quote of $0.3925 per pound plus a $0.05 per pound addition. The quote is from a dealer who would get the steel from Inland Steel. [Note added in proof: We need to add $0.05 to $0.006 for coating.] TD got some samples of this steel last fall in anticipation of the BTeV intersection region work at C0 and have measurements of the samples. 200,000 pounds would be a single melt. Lead time would be about eight weeks after receipt of order, so with procurement paperwork and bidding time twelve weeks is expected. [200K x $0.50 = $1000K]

A budgetary quote on the laminations was $21K for the die and $0.30/lamination for stamping. [(84/.0598) x 4 x 9 x 1.05 x $0.30 + $21K = $37K] Lead time is about twelve weeks.

We will have some conductor left over after the spare Main Injector quad project, but not enough for all these magnets. In any case, it is in inventory and would need to be bought out. This would give us a chance to accelerate coil winding if the tooling were available before the conductor arrived. Lead time for the conductor is about twelve weeks. Recent copper purchases have been in the neighborhood of $2.45/pound. These magnet use about 350 kg/magnet.
[350 x 2.2 x $2.45 x 9 = $17K]

The beam tube is a big uncertainty. There are 38 4Q120 beam tubes in our inventory. [Note added in proof: There are actually only 19 beam tubes in inventory.] If those are acceptable, or could be reformed a little, they are available. If we want something else, the usual process is to roll a sheet of stainless steel into a tube, weld it, clean up and treat the weld, then pull the tube through a series of dies to form it to the desired shape. We specify the permeability of the welds and their location(s).

Dave Johnson showed a freshly drawn picture of the Lambertson profile along with a 4Q120 beam tube and several beams. For the injected beam, he assumed a 40-pi emittance and plotted the 4 sigma contour. For the NuMI beam, he assumed 30-pi and showed the 3 sigma contour, both circulating and extracted. The Lambertson had been moved 10 mm from its current location, but the NuMI orbit had not been changed. The 4Q120 beam tube seemed just barely adequate, but matched reasonably well the 50 mm point where the field started to deteriorate in Vladimir's first model. Much discussion ensued on the desirability of additional aperture and the possibility of moving the Lambertson even farther (and then needing to realign NuMI).

Francois showed calculations of the magnetic field in a Main Injector quadrupole of uncertain heritage. This version had an octupole of about +1 unit at an inch and 12-pole of about -2 units. The good field region (field within $1x10^{-3}$) was independent of excitation.

Dave had found the off-center measurement of a BQA (48" version of the Main Ring quads) from 10 years ago. He hadn't had time to interpret the harmonics data, but the probe used and the probe center positions would extend the region over which the field was measured from the standard of about 28 mm to about 43 mm. Barring any serious abnormalities, the extrapolation to

50 mm should be reasonably good. With a quad currently on the test stand, MTF could make a stretched wire measurement out to the edge of the beam tube.

Vladimir just received yesterday afternoon steel measurement data on the some material known as AKA60. In general the B-H curve appears to be "better" than the Main Injector steel from LTV. Applying the new curve led to much less saturation than the calculations using Main Injector steel numbers, even better than the linearity of the Main Injector quadrupoles themselves. The calculations using a Main Injector steel B-H curve are somewhat suspicious in that the magnet excitation stops tracking at very low excitation. The AKA60 steel B-H curve needs a little massaging to be sure that it is appropriate (average upper and lower arms). The field uniformity was independent of the steel choice.

John Carson showed a magnet cross section with more detail The trim coil has 20 turns of #11 square copper, the equivalent of #10 round. The trim coil will come with an ML coating. The main conductor will get a half lap of 7-mil glass tape, then the package will get two half-lapped layers of ground wrap, and the whole thing will be vacuum impregnated. The four quarter cores will be stacked independently. A light, continuous weld will draw the laminations against a precision tie bar, as was done for the ILA (Main Injector Lambertson), in both directions. An alignment notch in the parting plane will mate with a precision alignment rod to hold adjacent quarters in place with respect to each other. The quarters will be joined with short welded tie plates that will provide access to the parting planes to verify good contact. A strip of G-10 between coil and core will give mechanical protection for the coil. An elastomer and epoxy between the coils will provide support but not deform the core during assembly.

Leon said that he had looked more carefully at the lead lengths required, and some are long enough that their resistance argues for 21 or 22 turns rather than 20. That can be done. John said that the trim coil is about 1000 feet, so the total resistance is about half an Ohm. Easiest would be to change to 22 turns with a slightly smaller gauge wire. Three layers instead of two would allow keeping the same size wire or even increasing the size.

Lucy is planning to check each of the potential installation locations during next week's shutdown.

TJ distributed a schedule that increased the production to a full nine magnets.

Next meeting in three weeks: Thursday, 1 April 2004. Same time, same place. At that meeting want to establish a baseline for the project.

1. A conceptual design of the magnet
2. A steel choice that can be released for procurement
3. A lamination profile that can be released for procurement
4. A conductor design that can be released for procurement
5. A beam tube design that can be released for procurement
6. A cost estimate
7. A refined schedule